A New Variety of *Chrysosplenium pseudofauriei* (Saxifragaceae) from Japan, and its Morphological and Cytological Characteristics

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**Abstract.** *Chrysosplenium pseudofauriei* H. Lév. (series *Sinica*), which has been known only from the northeastern part of the Asiatic continent and Cheju-do (Quelpart Isl.), was newly found in Shikoku, Japan, isolated from the main distribution area. It was examined morphologically and cytologically, and compared with materials obtained from Korea and with herbarium specimens. The Japanese plants were recognized as a new variety of the species. This new variety, var. *nipponense*, is distinguished from var. *pseudofauriei* in having smaller rosette leaves at the tip of sterile branches after flowering, remarkably saccate calyces, the styles about half as long as the calyx lobes, smaller seeds, the constricted structure of papilae on the seed surfaces, and larger chromosomes at metaphase. The chromosome number of the species was counted as $2n=24$ for the first time.

**Key words:** *Chrysosplenium pseudofauriei*, cytology, morphology, Saxifragaceae

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According to Hara (1957), *Chrysosplenium pseudofauriei* H. Lév. is included in ser. *Sinica* with another species, *C. sinicum* Maxim., occurring in northwestern China, and it is distributed in the northeastern part of the Asiatic continent and Cheju-do (Quelpart Isl.). No record of the series has been known from Japan. However, I found recently that *C. pseudofauriei* occurred in Shikoku, Japan, isolated from the main distribution area on the Asiatic continent.

For understanding the characteristics of the Japanese plants, detailed morphological and cytological observations were made, comparing with the Korean plants. The seeds and the gross morphology were also examined from many herbarium specimens. From these observations, I concluded that the plants of Japan should be recognized as a new variety of the species.

This paper aims to provide these morphological and cytological results and describe this new variety, var. *nipponense*.

**Materials and Methods**

*Chrysosplenium pseudofauriei* in Japan was first collected by S. Takafuji (no. 327) on 17 May 1966 at Mt. Eboshi, Higashi-iyayama-mura, Miyoshi-gun, Tokushima Prefecture (Figs. 1, 9), and the specimen had...
Fig. 1. Geographical distribution of *Chryosplenium pseudojuriei*. Shaded area shows the distribution area reported by Hara (1957). A dot indicated by arrow is the site where *C. pseudojuriei* occurs in Japan. Solid triangle indicated by arrowhead shows Mt. Soraksan, Korea, where plants examined in this study were obtained. A star shows the type locality (Wonsan) of the typical variety.

long been deposited in KYO, remaining unexamined, until I recently found it. I made a field survey on 1 May 1993 to confirm its occurrence there. A population of *C. pseudojuriei* was found on a moist and rather sunny slope (about 1300 m altitude) near Mt. Eboshi, and was crowded within several square meters. The flowers, just in full blossom, were yellowish (Fig. 10). These plants were cultivated for further analyses at the experimental garden of the Makino Herbarium, Tokyo.

The fresh Korean materials were collected by M. Ito et al. on October
3, 1994 at Mt. Soraksan, Kang-won-do (Fig. 1), and cultivated in the same experimental garden.

Detailed observations of flowers, capsules and seeds, and cytological analyses were made from the cultivated plants or from those fixed in FAA. The voucher specimens used for the cytological study are kept in MAK.

Herbarium specimens kept in KYO, TI and TNS were also examined for understanding the variability of size of rosette leaves, seed size and seed surface structure. Measurements of rosette leaves were made from the largest leaf blade in specimens from the same locality.

Floral morphology, seed surface structure and cytology of *Chrysosplenium grayanum* Maxim. (ser. *Nepalensia*), considered by Hara (1957) to be closely related to *C. pseudofauriei*, were also studied for comparison, since no materials of *C. sinicum* were available in the present study.

**Results**

*Habit and rosette leaves*

The flowering stems of *Chrysosplenium pseudofauriei* from Japan are 4–7 cm tall at anthesis. They have a few sterile branches at the base (Fig. 2a). No basal leaves were present because of their decay at anthesis. The leaves are light green and thin in texture. After flowering the sterile branches develop and elongate on the ground, forming a rosette with two pairs of large leaves at the tip (Figs. 2b, 9). The rosette leaves are broadly obovate or orbicular, and reach 3 cm long by 2.4 cm wide, and have somewhat numerous (30–36) incurved teeth along the margin. The plants are glabrous except for lanuginose hairs in the axil of the rosette leaves, which is a feature distinguishing it from *C. sinicum*, a quite glabrous plant.

In plants of *Chrysosplenium pseudofauriei* from Mt. Soraksan, Korea, on the other hand, the rosette leaves at the tip of the sterile branches are usually obovate and become distinctly larger, reaching 8 cm long and 5 cm wide (Fig. 2c).

The isotype specimens of var. *pseudofauriei* from Korea, kept in KYO, have rosette leaves 5.9 cm long by 3.7 cm wide. In other herbarium specimens examined, the rosette leaves are mostly 4–7 cm long and 2.3–5.1 cm wide, and rarely 3–3.5 cm long and 2.2–2.8 cm wide in a few specimens.

*Flowers and capsules*

Fig. 3 shows the shape of flowers, capsules, and stamens just before dehiscence in Japanese and Korean *Chrysosplenium pseudofauriei* and *C. grayanum*. In each flower, side views (b, g, l), longi-sectional views (c, h, m), and top views (a, f, k) showing the tetramerous arrangement of the floral parts are illustrated. The flowers of Japanese *C. pseudofauriei* (a, b, c) have erect calyx lobes and eight stamens. The calyces are yellow, and distinctly saccate and swollen because of the presence of an air chamber between the epidermis and the inner tissue. The ovaries are
Fig. 2. Habits of Chrysosplenium pseudofauriei. a, b: C. pseudofauriei var. nipponense (Wakabayashi 93045, 93045). c: C. pseudofauriei var. pseudofauriei in Mt. Soraksan, Korea (Ito et al. W-941050). a: Individuals at flowering time. b, c: Individuals after flowering, with capsules, showing elongated heterophyllous sterile branches, at apex of which larger rosette leaves develop.
Fig. 3. Flowers and capsules of Chrysosplenium pseudoauriei and C. grayanum. a–e: C. pseudoauriei var. nipponense (Wakabayashi 93045). f–j: C. pseudoauriei var. pseudoauriei (Ito et al. W–941050). k–o: C. grayanum (Wakabayashi 79029). a, f, k: Top views of flowers. b, g, l: Side views of flowers. c, h, m: Longisectonal views of flowers. d, i, n: Stamens showing adaxial (left) and abaxial (right) views, respectively. e, j, o: Capsules. Scale bars 1), 2) and 3) = 2 mm for stamens, flowers, and capsules, respectively.
completely inferior, forming distally rather slender styles ending in pointed stigmas. The styles are about half as long as the calyx lobes. The stamens (d) are as long as, or shorter than the calyx lobes, about 1.5 mm long; the filaments are about 1.5 times longer than the anthers; the anthers are yellow. The capsule (e) is unequally bilobed; the lobes are obliquely ascending, with rather long styles 0.8–1.2 mm long at the tip; the persistent filaments are about half as long as the calyx lobes.

The flowers of the Korean plants (f, g, h) differ from those of the Japanese ones, especially in the shape of the calyces and in the relative length of the styles to the calyx lobes. The calyces are greenish yellow and never become saccate. The styles are about as long as the calyx lobes at anthesis or slightly longer. Moreover, the disc of flower is more developed. The features of the stamens (i) and the capsules (j) are almost the same as in Japanese plants, although the lobes of the capsules are larger.

The floral and capsule structures of Chrysosplenium grayanum are clearly different from those of the Japanese and Korean C. pseudofauriei. The flowers of the former species are much smaller in size, having very short styles and only four stamens (k, l, m). The stamens (n) are also short, about 0.7 mm long; the filaments are shorter than the anthers. The capsule (o) has very short styles, about 0.3 mm long, on top of the ascending lobes.

Seeds

According to Hara (1957), the seeds of Chrysosplenium pseudofauriei are oval-globose, 0.7–0.8 mm long, minutely papillose on the surface and without longitudinal ridges. This surface structure of seeds is rare in the species group with opposite leaves, which is found only in ser. Sinica and in some species in ser. Nepalensis. The seed surface of C. pseudofauriei (materials from Russia) has been observed in detail using SEM (Kaplan and Strohschneider, 1984). The largest papillae on the surface have been shown to be about 17 μm long, cylindrical in form, and hollow at the tip.

Figs. 4 and 5 show the seed surface structure and the papillae of Chrysosplenium pseudofauriei from Japan and from Mt. Soraksan, Korea, and C. grayanum, observed with SEM. The seeds of C. pseudofauriei from Japan are oval, 600–700 μm long, with minute papillae on the scabrous surfaces (Fig. 4a, b). The papillae are 12–20 μm long and once (or twice) constricted to form roundish heads (Figs. 4b, 5c). This structure of the papillae differs from the report by Kaplan and Strohschneider (1984), and constricted papillae have not been known so far in any species of the genus.

On the other hand, the seeds of Chrysosplenium pseudofauriei from Mt. Soraksan, Korea, are oval-globose and larger (700–800 μm long) than those from Japan and have minute papillae on the scabrous surfaces (Fig. 4c, d). The papillae are usually 8–12 μm long, cylindrical in form and hollow at the tip (Figs. 4d, 5a). This structure of the papillae is congruent with the report by Kaplan and Strohschneider (1984). It is occasionally found that the cylindrical papillae reach 17 μm long and the tip is truncate or obtuse without a hollow (Fig. 5b).
As far as I have observed, the size of seeds from herbarium specimens of var. pseudoaurieii collected from the Asiatic continent and Cheju-do falls between 700 and 840 μm in length; the isotype specimens from Korea have seeds 750–800 μm long. The papillae of the seed surfaces from the isotype are cylindrical in form, having a hollow at the tip, and the largest ones reach 25 μm long (Fig. 6a). This structure resembles well those of plants from Mt. Soraksan. The other examined herbarium specimens from the Asiatic continent have cylindrical papillae with a hollow or
Fig. 5. Structure of papillae on seed surface of Chrysosplenium pseudofauriei and C. grayanum. a, b: C. pseudofauriei var. pseudofauriei from Mt. Soraksan, Korea (Ito et al. W-941050). c: C. pseudofauriei var. nipponense (Wakabayashi 93045). d: C. grayanum (Wakabayashi 941019). Scale bar=5 μm.

truncate or obtuse tip (ex. Fig. 6b, c) similar to those of plants from Mt. Soraksan. The seed papillae from specimens of Cheju-do have a rather roundish head constricted slightly at the base of the head (Fig. 6d), but these constrictions are not as distinct as those of the Japanese plants.

The seed surface structure of Chrysosplenium grayanum (ser. Nepalensis) have also been reported in detail based on SEM (Kaplan and Strohschneider, 1984; Kato and Shimizu, 1989). In Fig. 4e, f and Fig. 5d the seed surface structure and papillae of C. grayanum are shown by SEM. The seeds are oval-globose, 650–700 μm long, having minute papillae on the glabrous surfaces (Fig. 4e, f). The papillae are 15–23 μm long and have a globose, rough head, which are spatulate in side view, at the tip (Figs. 4f, 5d). This observation is nearly the same as those of the above authors. This structure of the papillae differs markedly from that of C. pseudofauriei.

Chromosomes
The somatic chromosome numbers counted in the present study are shown in Table 1. The chromosome number of Chrysosplenium
pseudofauriei has been confirmed to be $2n=24$ in both Japanese and Korean individuals. This is the first report for ser. Sinica. The chromosome number of *C. grayanum* (ser. Nepalensis) was $2n=22$, in accordance with the previous reports (Hara and Kurosawa, 1963; Funamoto and Tanaka, 1989).

**Table 1.** Chromosome numbers of *Chrysosplenium pseudofauriei* and *C. grayanum* counted in the present study.

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Chromosome number (2n)</th>
<th>Locality</th>
<th>Voucher specimen number*</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>C. pseudofauriei</em> H. Lév. var. pseudofauriei</td>
<td>24</td>
<td>Mt. Soraksan, Kang-won-do, Korea</td>
<td>W-941050 (MAK)</td>
</tr>
<tr>
<td>var. nipponense Wakab.</td>
<td>24</td>
<td>Higashi-iyayama-mura, Tokushima Pref., Japan</td>
<td>93045 (MAK, TI)</td>
</tr>
<tr>
<td><em>C. grayanum</em> Maxim.</td>
<td>22</td>
<td>Kiyomi-mura, Oono-gun, Gifu Pref., Japan</td>
<td>943028 (MAK)</td>
</tr>
</tbody>
</table>

*Collection number of Wakabayashi
The chromosomes of *Chrysosplenium pseudofauriei* and *C. grayanum* are shown in Fig. 7. The chromosomes of *C. pseudofauriei* occurring in Japan (a, a') are rather small, ranging from 1.0 \( \mu \text{m} \) to 1.3 \( \mu \text{m} \) in length at metaphase, while those from Mt. Soraksan, Korea, (b, b') are very small,
0.6 \mu m to 1.0 \mu m in length at metaphase. There is a gap in chromosome length between these plants. The chromosomes of C. grayanum (c, c') are also rather small, ranging from 0.7 \mu m to 1.3 \mu m in length, and one pair of chromosomes with satellites is observed.

Fig. 8 shows the karyotypes of Japanese Chrysosplenium pseudofauriei and C. grayanum, in which, for convenience, sm (submedian centromeric), st (subterminal centromeric) and t (terminal centromeric) chromosomes are arranged in the first row and m (median centromeric) chromosomes in the second row. In C. pseudofauriei (A), there are four pairs of t-sm chromosomes (nos. 1–4) and eight pairs of m chromosomes (nos. 5–12) in a set. C. grayanum (B) has seven pairs of t-sm chromosomes (nos. 1–7) and four pairs of m chromosomes (nos. 8–11), one pair of which (no. 9) has satellites. These two species are clearly different from each other also in karyomorphology as well as in chromosome number.

**Discussion**

The present Chrysosplenium plants found in Shikoku, Japan, are included in ser. Sinica by having glabrous and opposite leaves, heterophyllous habit with large rosette leaves at the tip of sterile branches, and papillose seeds with no longitudinal ridges. According to Hara (1957), C. sinicum differs from the other species of this series, C. pseudofauriei, in having shorter stamens (0.7–1 mm long against 1.2–1.5 mm long in the latter species), shorter styles on the capsule (0.4–0.7 mm long against 0.8–1.2 mm long), slightly smaller seeds (0.6–0.7 mm long against 0.7–0.8 mm long), fewer teeth on the rosette leaves (5–9 teeth on each side against 8–20 teeth on each side), and hairs absent in the axils of rosette leaves (against present in the latter species). Therefore, the plants
of ser. *Sinica* found in Shikoku, Japan, belong to *C. pseudofauriei*, according to the species delimitation by Hara (1957). The smaller size of the seeds (0.6–0.7 mm long) in the Japanese plants should be regarded as seed size variation within *C. pseudofauriei*.

The fact that *Chrysosplenium pseudofauriei* occurs also in Shikoku, Japan, may suggest that the species was once widespread southward into southwestern Japan from the northeastern Asiatic continent or that seeds of Asiatic mainland plants had reached Japan by long distance dispersal. Differences between the mainland and Japanese plants could then be attributed to “founder effect”, where the limited genetic diversity of the newly arrived Japanese plants later diverged from the mainland ancestors. It has been known that a land bridge or land connection existed during the Quaternary between the Korea Peninsula and Kyushu which connected also with Shikoku and Honshu (Minato et al., 1965). With warming and rising sea levels after the Ice Age, the Japanese plants would have been isolated by the Korea Strait from those of the Asiatic continent. The present site in Shikoku where the species still survives (Fig. 1) might be a refugium for this relic population.

As mentioned above, the individuals in Japan more or less differ from those in Korea in several characteristics. The rosette leaves of the Japanese individuals are 3 cm long and 2.4 cm wide. In individuals from Mt. Soraksan they reach 8 cm long and 5 cm wide. According to Hara (1957), the rosette leaves of the variety from Amur, Ussuri, northeast China and Korea are 3–7 cm long and 1.8–5.5 cm wide, and plants from southern Korea sometimes have smaller rosette leaves. The leaf blades of most herbarium specimens, including the isotype of var. *pseudofauriei*, fall within 4–7 cm long by 2.3–5.1 cm wide. Plants with smaller rosette leaves are from Taebaek, Kang-won-do (3.5 cm long, 2.8 cm wide), and Yangdog, P’yong-an-nam-do (3 cm long, 2.2 cm wide), in Korea. Plants having smaller rosette leaves may, therefore, not always be restricted in southern Korea, although much more materials are necessary for understanding the geographical variation in size of the rosette leaves. At any rate, the rosette leaves of the Japanese plants are considered to be the smallest within the species. The same pattern can also be seen in seed size (600–700 μm long in Japanese plants and 700–840 μm long in plants from the Asiatic continent and Cheju-do).

The constricted papillae with roundish heads on the seed surfaces in plants from Japan are not found in plants from the Asiatic continent, where the seed papillae are cylindrical with hollow or truncate or obtuse tips. Plants from Cheju-do somewhat approach those of Japan in having rather roundish heads on the papillae, but the constrictions are inconspicuous.

Flower shape and the size of chromosomes at metaphase in plants from Japan also differ from those of Mt. Soraksan, Korea. The calyces are remarkably saccate in plants from Japan, while no such a feature is observed in those of Mt. Soraksan. Plants from Mt. Soraksan have styles about as long as or slightly longer than the calyx lobes at anthesis; Japanese plants have styles about half as long as the calyx lobes. The chromosomes of the Japanese plants at metaphase are larger than those of
plants from Mt. Soraksan (the former 1.0–1.3 μm, the latter 0.6–1.0 μm in length), although the number, 2n=24, is the same. The floral and cytological features of plants from Mt. Soraksan are considered to be typical of Chrysosplenium pseudofauriei from the Asiatic continent, since plant from Soraksan are similar in form and size of the rosette leaves and seed surface structure to the type specimen of C. pseudofauriei var. pseudofauriei (N. Korea, Hamgyongnam-do, Wonsan, July 4, 1906, Faurie, 379).

Because of the differences cited above, I recognize the Japanese plants as a new variety, var. nipponense, of Chrysosplenium pseudofauriei.

**Taxonomic treatment**


Leaves opposite. Glabrous, except rusty-lanuginose in axils of rosette leaves. Rhizome and basal leaves decayed at anthesis. Sterile branches well developed and elongate after flowering, forming a rosette with 2 or 3 pairs of large leaves at apex; rosette leaves obovate, broadly obovate or orbicular, 3–8 cm long, 2.2–5 cm wide, obtusely serrate with somewhat incurved, sometimes doubled, numerous (15–25) teeth on each side. Flowering stems 4–15 cm tall, with 2 or 3 pairs of leaves. Cyme compact. Bracteal leaves yellowish at anthesis. Flowers campanulate, 3–4 mm in diameter, yellowish or greenish yellow. Calyces sometimes saccate; lobes erect. Stamens 8, as long as or shorter than calyx lobes, 1.4–1.5 mm long; filaments ca. 1.5 times longer than anthers; anthers yellow. Ovaries completely inferior. Disc developed or inconspicuous. Styles subulate, ending in pointed stigma, ca. as long as or slightly longer than calyx lobes, or ca. half as long as calyx lobes. Capsules unequally bilobed; lobes obliquely ascending, with rather long styles at tops; styles 0.8–1.2 mm long; persistent filaments shorter than calyx lobes. Seeds oval, 0.6–0.84 mm long, with minute papillae on scabrous surface; papillae 8–25 μm long. Chromosome number 2n=24.

**Distribution.** Amur, Ussuri, northeast China, Korea, and Shikoku, Japan.

**Key to varieties of Chrysosplenium pseudofauriei**

Rosette leaves after flowering obovate or broadly obovate, mostly 4–8 cm long by 2.3–5 cm wide; calyces not saccate; styles as long as or slightly longer than calyx lobes; seeds 0.7–0.84 mm long; papillae on seed surface cylindrical, with hollow or truncate or obtuse tips .......... var. *pseudofauriei*

Rosette leaves after flowering broadly obovate or orbicular, no more than 3 cm long, 2.4 cm wide; calyces remarkably saccate; styles ca. half as long as calyx lobes; seeds 0.6–0.7 mm long; papillae on seed surface (once-) twice constricted, forming roundish heads. .......... var. *nipponense*

*Chrysosplenium pseudofauriei* var. *pseudofauriei*

Sterile branches well developed and elongate after flowering, forming a rosette with 2 or 3 pairs of large leaves at apex. Rosette leaves obovate or broadly obovate, 3–8 cm long, 2.2–5 cm wide, with 15–25 teeth on each side. Flowering stems 6–15 cm tall. Flowers yellowish or greenish yellow. Calyces not saccate. Stamens ca. 1.4 mm long. Disc developed. Styles as long as or slightly longer than calyx lobes. Persistent filaments in capsules somewhat shorter than calyx lobes. Seeds 0.7–0.84 mm long; papillae 8–25 μm long, cylindrical, with hollow, truncate or obtuse tips. Chromosomes 2n=24 in number, 0.6–1.0 μm long at metaphase.

**Distribution.** Amur, Ussuri, northeast China (Heilongjiang, Jirin), and Korea.

**Representative specimens examined.**


Chrysosplenium pseudofauriei var. nipponense Wakab., var. nov.

A typo foliis rosularibus minoribus, seminibus minoribus, et calycibus valde saccatis differt.


Sterile branches well developed and elongate after flowering, forming
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**FIG. 9.** Holotype specimen of *Chrysosplenium pseudofauriei* H. Lév. var. *nipponense* Wakab. (KYO).

a rosette with 2 pairs of large leaves at apex. Rosette leaves broadly obovate or orbicular, ca. 3 cm long, 2.4 cm wide, with 15–18 teeth on each side. Flowering stems 4–7 cm tall at anthesis, ca. 10 cm tall after flowering. Flowers yellowish. Calyces distinctly saccate. Stamens ca. 1.5 mm long. Disc inconspicuous. Styles ca. half as long as calyx lobes. Persistent filaments in capsules ca. half as long as calyx lobes. Seeds 0.6–0.7 mm long; papillae 12–20 μm long, (once-) twice constricted,
Fig. 10. Flowering plants of *Chrysosplenium pseudofauriei* var. *nipponense* in the field in Higashiyayama-mura, Miyoshi-gun, Tokushima Prefecture, Japan. Photographed on May 1, 1993.
forming roundish heads. Chromosomes 2n=24 in number, 1.0–1.3 μm long at metaphase.

*Japanese name.* Hime-ooiwabotan.

*Distribution.* Known only from Higashi-iyayama-mura in Tokushima Prefecture, Shikoku, Japan.


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**References**


**要旨**

若林三千男：ネコノメソウ属オオイワボタン (ユキノシタ科) の新変種ヒメオオイワボタン

ネコノメソウ属 *Sinica* 列のオオイワボタン (和名：Suto, 1935) *Chrysosplenium pseudofauriei* は、アジア大陸東北部、および千葉県にのみその分布が知られていたが、最近、大陸から遠く離れた四国徳島県にも自生していることが明らかとなった。このように隔離されて存在する日本産オオイワボタンがどのような特徴をもっているのかを理解するため、この種の基準標本を含む多くの乾燥標本や韓国産オオイワボタンとの形態学的、細胞学的比較検討を行った。その結果、日本産のものは新変種と認識し、ヒメオオイワボタン var. *nipponense* と命名、記載した。ヒメオオイワボタン (ヒメ) はオオイワボタン (オオ) と比べ
花はヒメでは萼が囊状に著しく膨れ、花柱は萼片の約半分である。また、種子表面の微細な突起の形状にも違いが見られ、オオでは突起が円柱状で先端に大きな穴が空いているか、まれに切頭形または鈍頭であるのに対して、ヒメでは突起は約2箇所でくびれており先端は球状である。中期染色体の大きさはヒメの方がやや大きい。染色体数はヒメ、オオとも2n =24であり、Sinica列としては初めての報告である。

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